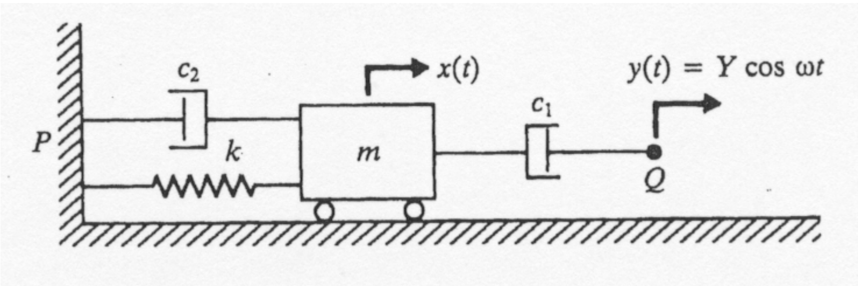
ME 370.1 Fall 2018 Name(s)

Homework 9

Due: *In class*, Friday Oct. 26

1. (32 pts) Examine the geometric model shown below, where $y(t)$ is a motion input applied at the right end of damper c_1. The math model for the system is $m\ddot{x} + (c_1 + c_2)\dot{x} + kx = c_1 \omega Y sin(\omega t + \pi)$



(1) (4 pts) The magnitude of the follow-up vibration $x_p(t) = X\sin(wt + \pi + \psi)$ is

a) $X = \dfrac{c_1 r Y}{m\omega_n} \dfrac{1}{\left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2}}$

b) $X = \dfrac{Y/\omega_n^2}{\left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2}}$

c) $X = \dfrac{c_1 Y}{m\omega_n^2} \dfrac{1}{\left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2}}$

d) $X = \dfrac{r^2 Y}{\left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2}}$

(2) (8 pts) The magnitude of the force $f_Q(t) = F_Q \sin(wt + \alpha)$ on damper c_1 is

a) $F_Q = \left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2} X$

b) $F_Q = \left[(k - m\omega^2)^2 + (c_2\omega)^2\right]^{1/2} X$

c) $F_Q = \left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2} kX$

d) $F_Q = \left[(k - m\omega^2)^2 + (c_2\omega)^2\right]^{1/2} c_1 X$

(hint: this force may be more easily obtained starting with the elemental equation of the mass).

(3) (5 pts) The magnitude of the force $f_P(t) = F_P \sin(wt + \beta)$ transmitted to the wall at point P is

a) $F_P = \left[k^2 + (c_2\omega)^2\right]^{1/2} X$

b) $F_P = \left[(k - m\omega^2)^2 + (c_2\omega)^2\right]^{1/2} c_2 X$

c) $F_P = \left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2} kX$

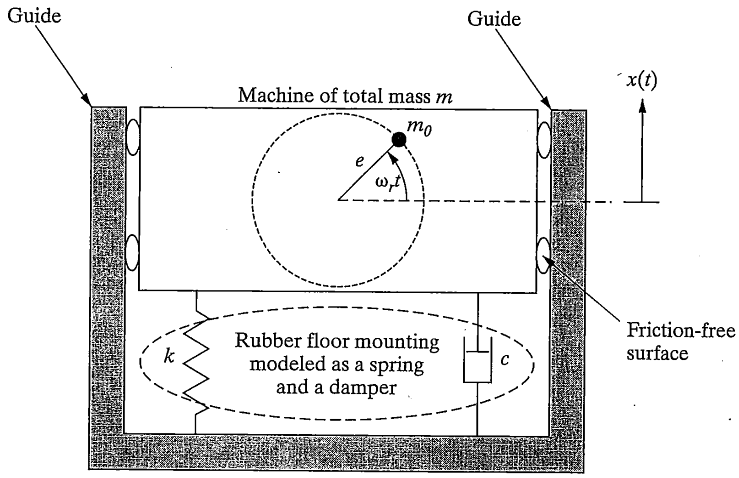
d) $F_P = \left[(1-r^2)^2 + (2\xi r)^2\right]^{1/2} X$

(4) (15 pts) Let $m = 10$ kg, $k = 1000$ N/m, $c_1 = 110$ N-s/m, and $c_2 = 25$ N-s/m. Program in matlab to plot X/Y vs. ω/ω_n and F_P/F_Q vs. ω/ω_n for r ranging from 0 to 2. Submit the matlab program and the plots. From the plots, use matlab data curser tool to determine the maximum values of X/Y and F_P/F_Q and the corresponding values of r:

max(X/Y) = ______________ corresponding r = _________________

max (F_P/F_Q) = _____________ corresponding r = _________________

2. (15 pts) A machine with a rotating unbalance, $m_o e$, is mounted on a rubber floor as shown. The total mass of the machine is $m_t = 120$ kg, the rubber-mount stiffness is $k = 8\times10^5$ N/m and damping constant $c = 9000$ N-s/m. The centrifugal force generated by the machine unbalance is determined to be $F_o = 600$ N when the machine operates at $\omega = 1500$ rpm.



(1) (2 pts) The machine unbalance in kg-m is

a) $m_o e = 0.024$ b) $m_o e = 0.042$

c) $m_o e = 0.064$ d) $m_o e = 0.092$

(2) (4 pts) The magnitude of machine vibration in millimeter is

a) $X = 0.11$ b) $X = 0.23$

c) $X = 0.45$ d) $X = 0.86$

(3) (4 pts) The magnitude of the force in Newton transmitted to machine foundation is

a) $F_{to} = 102$ b) $F_{to} = 243$

c) $F_{to} = 377$ d) $F_{to} = 458$

(4) (5 pts) To reduce the transmitted force by 25%, the damping constant, *c*, in N-s/m of the rubber floor needs to be at least

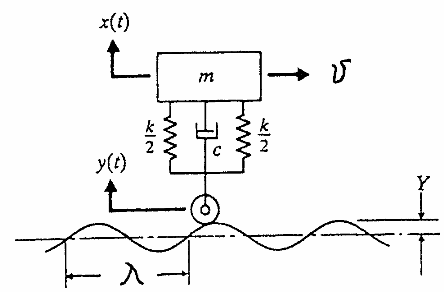
a) larger than 10410

b) larger than 12540

c) smaller than 4558

b) smaller than 6758

3. (10 pts) A vehicle is traveling through a road segment of wavy pavement and develops an uncomfortable bouncing vibration of magnitude $X = 0.1\,\mathrm{m}$. The pavement may be described by a sine wave of amplitude $Y = 0.1\,\mathrm{m}$ and wavelength $\lambda = 3.0\,\mathrm{m}$. The bouncing vibration of the vehicle may be meaningfully modeled by the SDOF model below



The governing equation was derived in class to be

$$m\ddot{x} + c\dot{x} + kx = Y\sqrt{k^2 + c^2\omega^2}\,\sin\omega t$$

Let $m = 500$ kg, $c = 10000$ N-s/m and $k = 2\times10^5$ N/m.

(1) (5 pts) The traveling speed of the vehicle in *mph* is

a) $v = 15$

b) $v = 20$

c) $v = 25$

d) $v = 30$

(2) (5 pts) To cut down the bounce to one quarter of the original value, the vehicle needs to at least travel

a) faster than 45 mph

b) faster than 90 mph

c) slower than 10 mph

d) slower than 12 mph